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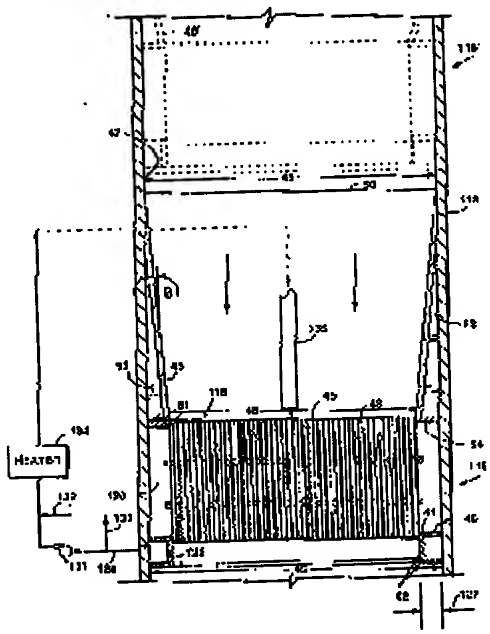
(54) **PRODUCTION DE PATE A PAPIER AU MOYEN D'UN LESSIVEUR A DIAMETRE ESSENTIELLEMENT CONSTANT**

(54) **CELLULOSE PULP PRODUCTION USING A SUBSTANTIALLY CONSTANT DIAMETER DIGESTER**



(57) La présente invention fait état d'un lessiveur vertical utilisé pour la fabrication de pâte chimique ou d'un autre récipient servant à traiter un coulis de matière cellulosique fibreuse fragmentée. Le coût de fabrication de l'enveloppe du présent lessiveur est considérablement réduit en raison de l'élimination des accroissements

(57) In a vertical digester for producing chemical pulp, or other vessel for treating a slurry of comminuted fibrous cellulose material, the cost of manufacturing the shell is significantly reduced by eliminating the external step increases in the digester shell. The digester shell has a substantially constant internal diameter from just below

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successifs externes de l'enveloppe. Cette dernière présente un diamètre interne essentiellement constant à partir de juste au-dessous de l'entrée jusqu'au-dessus de la sortie. L'enveloppe comprend des tamis dans des passages de transition internes (p. ex., coniques) ayant des angles de convergence de moins de 40° (p. ex., environ 10 à 25°) au-dessus de chaque tamis, de sorte que le coulis passe par le passage de transition de façon uniforme et sans voûtage. Elle comporte également un accroissement progressif ou un autre type d'accroissement du diamètre, qui ramène celui-ci, après le tamis, à sa dimension d'origine.

the inlet to just above the outlet, screen assemblies being provided by an internal transition (e.g. conical) having an angle of convergence of less than 40° (e.g. about 10-25°) above each screen assembly so that the slurry flows through the transition without bridging or hang-up, and a step increase, or other increase, in diameter back to the first diameter after the screen assembly.

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CELLULOSE PULP PRODUCTION USING A SUBSTANTIALLY CONSTANT DIAMETER DIGESTER

BACKGROUND AND SUMMARY OF THE INVENTION

In the art of chemical pulping of comminuted cellulosic fibrous material, for example wood chips, the material is typically treated with cooking chemicals under pressure and temperature in one or more cylindrical vessels, known as digesters. This treatment can be performed continuously or in a batch mode. In the continuous mode, chips are continuously fed into one end of a continuous digester, treated, and continuously discharged from the other end. In the batch method, one or more batch digesters are filled with chips and cooking chemical, capped and then treatment commences. Once the treatment is finished the contents of the batch digester are discharged. In either batch or continuous digesters, a slurry of comminuted cellulosic fibrous material and cooking chemical moves through a cylindrical vessel.

In both continuous and batch digesters, in order to uniformly distribute both temperature and cooking chemical, cooking liquor is typically circulated through the slurry of chips and liquor, typically referred to as "the chip column". This circulation is typically effected by some form of screen, located along the internal surface of the cylindrical vessel, a pump, a heater, and a return conduit. The screen retains the material within the digester as the liquor is removed, augmented with other liquors and/or a portion thereof removed, pressurized, heated, and then returned to the slurry in the vicinity of the screen or elsewhere.

This radial removal of liquor typically produces radial compression of the chip column in the vicinity of the screen assembly. In addition, the weight of the column of chips above the chips near the screen introduces another source of compression of the chips. Furthermore, the vertical movement of free liquor in the chip column, either upward or downward, can vary the compression load, or compaction, of the chip column. It is known in the art that this radial and vertical compression can interfere with the uniform movement of the chip column, which is so essential for the uniform treatment of the chips. For this reason, conventional digesters and screen assemblies are designed so that the diameter of the flow path increases just below the screen. This increase in diameter or "step out" relieves the compression in the chip column and permits more uniform movement of the column. This step out typically consists of a radial increase of about 6 inches to 2 feet.

However, this increase in diameter of the vessel, requires that the diameter of the vessel shell include a step increase in diameter and also, typically, a conical transition in the shell to transition from the smaller diameter to the larger diameter. Both the non-uniform shell diameter and the additional welding necessary to accommodate the conical transition, among other things, can dramatically impact the cost of manufacturing a digester vessel. It would be highly advantageous to reduce the cost of manufacturing the shell of a digester by making such step increases in the digester shell unnecessary.

In addition, since the cylindrical column of chips typically does not conform to the increased diameter of the vessel, these step outs can provide an undesirable flow path for cooking liquor around the chip column, or can permit the chip column to collapse into the void created. This channeling of liquor can promote non-uniform treatment by causing

non-uniform heating and non-uniform liquor distribution. The collapse or channeling of chips can also result in non-uniform treatment. Non-uniform treatment can be manifested in undercooking of chips (i.e., increased rejects), increased cooking chemical consumption, and reduced fiber strength, among other things. It thus also would be desirable to provide a method and apparatus for cooking comminuted cellulosic fibrous material so that channeling is minimized and uniform treatment of the chips enhanced.

In U.S. patent 4,958,741 a novel vessel geometry is disclosed for handling particulate material, for example, grain. U.S. patents 5,500,083; 5,617,975; and 5,628,873 disclose very effective methods and devices for applying the general techniques disclosed in the 4,958,741 patent to the handling and treatment of comminuted cellulosic fibrous material in the pulping industry. Specifically, patents 5,500,083, 5,617,975, and 5,628,873 disclose methods and systems for uniformly treating and discharging material from vessels without the aid of mechanical agitation. Typically, the disclosed vessels for handling comminuted cellulosic fibrous material, known, for example, as chip bins, have outlets that are smaller in cross sectional area than the main body of the vessels and use transitions having geometries exhibiting one-dimensional convergence and side relief. This technology is marketed under the name Diamondback® by Ahlstrom Machinery Inc. of Glens Falls, NY.

As described in the 4,958,741 patent and elsewhere, the flow of particulate material through a vessel can be characterized as "mass flow" or " funnel flow". During mass flow, when any material is withdrawn from the vessel essentially all the material in the vessel moves. For funnel flow, when material is withdrawn, a portion of the material (generally in the center of the vessel) moves substantially faster than the material at

the periphery. In the most severe cases, this flow pattern is referred to as "channeling" or "rat-holing". For right conical transitions or outlets, mass flow is ensured when the angle of convergence of the transisotn does not exceed a certain angle which is material dependent, known as the material's "critical mass- flow angle". Conical convergences having larger angles, that is, flatter cones, tend to produce non-uniform funnel flow. The critical mass-flow angle is typically determined experimentally using samples of the material that is to be passed through the vessel.

Of course, in the treatment of comminuted cellulosic fibrous material, mass flow is preferred. It is possible to prevent channeling and rat-holing by designing vessels with convergence angles less than or equal to the critical mass-flow angle for the material being transported. For wood chips in a chip bin, this angle is relatively shallow, for example, less than 30 degrees. Building a chip bin for a desired retention time but having such a shallow convergence to a desired outlet diameter requires that the bin be uneconomically tall. However, for the relatively small reductions in cross section required for a digester screen assembly, these shallow critical convergence angles can be used to simplify the construction and reduce the cost of digester vessels, without interfering with the stable function of the digester. In one embodiment of this invention, right conical transitions having angles of convergence less than the critical mass-flow angle are introduced to pulp digesters to aid in accommodating the use of screen assemblies in the digesters.

U.S. patent 4,958,741 introduces a geometry known as "one-dimensional convergence and side relief" which permits "mass flow" within vessels while exceeding the critical mass flow angle. By employing one-dimensional convergence geometry, reductions in vessel diameter can be achieved, while maintaining mass flow, that would require much longer

transitions to achieve using a right conical transition. Typically, to avoid such undesirable transitions lengths, conical transitions are designed with angles greater than the critical mass flow angle but are agitated to prevent or minimize bridging or hang-up. In another embodiment of this invention, transtions exhibiting single-convergence and side relief are employed in pulping digesters to aid in accommodating the use of screen assemblies in the digesters.

Conical converging transitions are not unknown in the art of continuous cooking. With the advent of counter-current treatment in the late 1950s and early 1960s, conical converging transitions were often used to accommodate screen assemblies introduced to the bottom sections of existing continuous digesters. One example of such a transition is shown in U.S. patent 3,429,773 which was filed in 1965.

Prior to the introduction of treatments in the bottom of the digester, such as the use of cooling dilution to reduce the temperature of the pulp during discharge, that is, "cold blowing", or counter-current treatment, for example, counter-current Hi-Heat™ washing (see U.S. patents 3,007,839; 3,097,987; 3,200,032; and 3,298,899), continuous digesters did not have screen assemblies in their lower sections. See for example U.S. patents 2,474,862; 2,459,180; 2,938,824 and 3,041,232. Typically, after co-current treatment throughout the length of the digester, the completely cooked pulp was typically discharged, or "blown", from the bottom of these early digesters while still hot, that is "hot blowing". In order to introduce and distribute cool liquor or to effect counter-current treatment, some form of liquor distributing circulation with a screen assembly was introduced to the lower part of existing digesters. Furthermore, in order to minimize the cost of such a "retro-fit", these screen assemblies were introduced to the bottom sections of existing digesters with conical

converging transitions, as shown U.S. 3,429,773. These conical convergences were solely introduced as a modification to existing structures. When such lower screens were and are used in newer digesters, in order to maintain the integrity and uniform movement of the chip column, some form of shell transition is used such that the internal surface of the screen is essentially flush with the internal diameter of the shell.

The conventional teaching in the art is that such conical convergences in any part of the digester, such as shown in U.S. 3,429,773, promote non-uniform movement or "hang-up" of the chip column and non-uniform treatment, and are to be avoided. Column movement was essentially ensured for screen assemblies located in the bottom of the digester, such as that shown in U.S. 3,429,773, by the presence of the rotating, discharge-aiding agitator, known as the "scraper", directly beneath the conical convergence. Any "bridging" that might develop due to the conical convergence above the screen was disrupted by the action of the scraper. This is also true of the conical convergence "collar" shown in U.S. patent 3,802,956. The present invention overcomes this misconception associated with convergences within the digester and provides a digester which is less expensive to manufacture. This invention also provides a means for introducing screen assemblies to existing vessels without requiring that the diameter of the vessel be enlarged at the location where the screen is introduced. This is especially true in locations where agitators are not present to aid in the movement of the chip column, for example, in cooking zones remote from the discharge of a digester.

Often, digester vessel schematics are drawn with uniform vessel diameters with representative screen assembly locations. For example,

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see U.S. patents 3,413,189; 3,445,328; and 3,427,218, or more recent U.S. patents 5,547,012; 5,489,363; 5,575,890; and 5,635,026. Clearly, these illustrations are schematic representations only and there is no intent to imply that actual vessels are built or can be built in this fashion, and would be understood as such by those of ordinary skill in the art. Those in the art understand that under present practice some form of chip column relief must be provided, otherwise the digester will not operate as desired.

Also, the prior art includes illustrations of digesters with uniform vessel diameters with screen assemblies having external cavities into which liquor is drawn. See for example U.S. patents 2,695,232 and 3,200,032. These illustrations depict digesters that do not provide the chip column relief that is so essential for proper chip column movement. Also, such constructions, as shown in U.S. 2,695,232, and 3,200,032 do not lend themselves to ease of design and manufacture since the external cavities are pressurized and their design must comply with pressure vessel design and manufacturing codes.

One embodiment of this invention takes advantage of the critical angle of convergence required for mass flow of a slurry of chips and cooking liquor to provide a digester having a uniform shell diameter while still providing the column relief that promotes the uniform movement of chips. According to one aspect of the present invention a digester (or other) vessel for cooking or treating comminuted cellulosic fibrous material in a liquid slurry (e.g. to produce cellulose pulp), the material having a critical angle of convergence, is provided. The vessel comprises: A substantially vertical vessel shell having a substantially constant first internal diameter. A first screen assembly mounted at an agitator-free location in said vessel and for removing liquid from the slurry,

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and including a second internal diameter smaller than the first internal diameter, and defining a screen cavity internal of the shell. A first transition above the first screen assembly between the first and second diameters, the first transition having an angle of convergence with respect to vertical. And, wherein the first transition angle of convergence is less than the critical angle of convergence of the liquid slurry cellulosic fibrous material, so that the slurry flows through the transition without bridging or hang-up, and without need for an agitator.

The vessel further comprises an increase in diameter to substantially the first internal diameter below the first screen assembly, the increase in diameter preferably being substantially immediately below the screen assembly and comprising a step increase.

The vessel also preferably further comprises a second screen assembly having a third diameter and disposed below the first screen assembly; and a second transition between the first diameter and the third diameter, the second transition having an angle of convergence less than the critical angle of convergence of the liquid slurry cellulosic fibrous material, so that the slurry flows through the transition without bridging or hang-up. The step increase in diameter is preferably provided to substantially the first internal diameter immediately below the second screen assembly.

As is conventional when the vessel is a digester (e.g. a continuous digester), the digester vessel also includes means for heating the liquid withdrawn from the first screen assembly and introducing the heated liquid adjacent the first screen assembly.

The first transition may include various geometries which permit the construction and use of vessels of uniform shell diameter. One preferred geometry comprises a substantially right conical transition,

although other transition geometries (including those such as described in the patents mentioned above) may be provided. The first transition angle of convergence is less than 40°, and preferably less than 30° perhaps even less than 10°, depending upon flow characteristics. Typically the first transition angle is between about 10-25°, preferably between 10-20°. All of the transitions provided preferably are conical and with angles of convergence of less than 40°.

The conical transition may also provide a screening surface. That is, the conical section may not be smooth and continuous but it may also be perforated. For example, in order to aid in the removal of liquid from the chip column, the conical convergence may comprise a perforated screen plate or parallel-bar-type screens, or the like. In addition, the conical screening surface may comprise the only screening surface in the screen assembly. That is, no cylindrical screen surface may be present below the cylindrical screen surface and the step increase to the first internal diameter may be located directly beneath the conical screening surface.

The increase in diameter below the screen assembly to the first internal diameter may also comprise a conical transition, in this case, a conical diverging transition. This diverging transition can minimize the formation of void spaces between the compressed chip column and the internal surface of the vessel and minimize column collapse and liquor channeling. This conical divergent transition may also be perforated. The removal of liquor via this lower conical screen transition can aid in drawing the compressed chip column out to the first internal diameter of the vessel.

The conical or cylindrical screening surfaces may be continuous in the circumferential direction or they may be interrupted by non-perforated

blank plates. For example, if the screen assembly comprises two or more levels of screens, the screen surface and the blank plates may alternate such that the screen surfaces at one level may align with the blank plates of another (e.g. adjacent) level. This pattern is typically referred to as a "checker board" screen arrangement. Of course, a single row of screens may also include blank plates. The blank plates are typically uniformly distributed.

Also blank plates may also be located between one horizontal level of screens and another or between one horizontal level of screens and a transition. These blank plates are known as "relief plates". For example, in screen assembly comprising a first conical converging transition, a right cylindrical screen section, and a second conical divergent screen section below the right cylindrical screen section, a horizontal blank relief plate may be located between the right cylindrical screen surface and the second conical divergent screen surface. This horizontal "relief" permits the compressed screen surface to "relax" or "recover" from being compressed by the liquor removal above before being drawn out by the liquor removal from the subsequent screen.

The first transition may also comprise or consist of a geometry known as "one dimensional -convergence geometry and side relief". As is clear from the descriptions provided in U.S. patent 5,500,083 and other patents. One dimensional convergence and side relief describes a configuration composed of two symmetrically oriented end surfaces that converge downward toward each other only in one dimension. Thus at any given cross-section, the surfaces will be reflections of each other around a horizontal center liner perpendicular to the singular direction of convergence. In its simplest form, the cross-section could be described by two parallel straight lines symmetrically oriented about a horizontal

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THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A vessel for treating comminuted cellulosic fibrous material in a liquid slurry, the material having a critical angle of convergence; said vessel comprising:

a substantially vertical vessel shell having a first internal diameter;

a first screen assembly mounted at an agitator-free location in said vessel and for removing liquid from the slurry, and including a second internal diameter smaller than said first internal diameter, and defining a screen cavity internal of said shell;

a first transition above said first screen assembly between said first and second diameters, said first transition having an angle of convergence with respect to vertical; and

wherein said first transition angle of convergence is less than the critical angle of convergence of the liquid slurry cellulosic fibrous material, so that the slurry flows through the transition without bridging or hang-up, and without need for an agitator.

2. A vessel as recited in claim 1 further comprising an increase in diameter to substantially said first internal diameter below said first screen assembly.

3. A vessel as recited in claim 2 wherein said increase in diameter is substantially immediately below said screen assembly.

4. A vessel as recited in claim 3 wherein said increase in diameter comprises a step increase.

5. A vessel as recited in claim 3 further comprising: a second screen assembly having a third diameter and disposed below said first screen assembly at an agitator-free location in said vessel; and a second transition between said first diameter and said third diameter, said second transition having an angle of convergence less than the critical angle of convergence of the liquid slurry cellulosic fibrous material, so that the slurry flows through the transition without bridging or hang-up, and without need for an agitator.

6. A vessel as recited in claim 5 further comprising a step increase in diameter to substantially said first internal diameter immediately below said second screen assembly.

7. A vessel as recited in claim 2 further comprising means for heating liquid withdrawn from said first screen assembly, and reintroducing heated liquid adjacent said first screen assembly.

8. A vessel as recited in claim 2 wherein said first transition comprises a substantially right conical transition, and wherein said first transition angle of convergence is about 10-25°.

9. A vessel as recited in claim 5 wherein said first and second transitions are both substantially right conical transitions, and wherein said first and second transition angles of convergence are both less than 40°.

10. A vessel as recited in claim 1 wherein said vessel comprises a continuous digester having a top and a bottom, with an inlet adjacent the top and outlet adjacent the bottom, and wherein said digester shell first diameter is substantially constant from just below said inlet to just above said outlet.

11. A vessel as recited in claim 1 wherein said first transition comprises a single non-symmetric one-dimensional convergence transition, including a triangular panel with a screen section of said screen assembly at least substantially immediately below said panel.

12. A vessel as recited in claim 1 wherein said first transition comprises a multiple symmetric one-dimensional convergence transition, including a pair of triangular panels with a screen section of said screen assembly at least substantially immediately below each of said panels.

13. A vessel as recited in claim 1 wherein said screen assembly comprises a discontinuous screen.

14. A vessel as recited in claim 1 wherein said first transition comprises multiple one-dimensional convergence transition elements.

15. A vessel as recited in claim 1 wherein said first transition comprises a plurality of eyebrow baffles.

16. A vessel as recited in claim 15 further comprising a screen section of said first screen assembly substantially immediately below each of said eyebrow baffles.

17. A vessel as recited in claim 1 wherein said increase in diameter is spaced from said first screen assembly a at least one of a diverging conical transition and a cylindrical relief plate.

18. A vessel as recited in claim 1 wherein said first transition also includes at least one screen section.

19. A method of treating a liquid slurry of comminuted cellulosic fibrous material under cooking conditions in a substantially vertical continuous digester having a top and a bottom and a first substantially constant internal diameter, to produce chemical pulp, comprising the steps of substantially continuously:

(a) introducing the slurry of comminuted cellulosic fibrous material into the digester adjacent the top thereof, to flow downwardly in the digester in a flow path;

(b) at at least one point along the digester which is devoid of an agitator, as the slurry moves downwardly in the flow path, causing the slurry of comminuted cellulosic fibrous material to transition from the first diameter of the flow path to a second flow path diameter smaller than the first diameter by at least about 2%;

(c) screening the slurry at the second diameter of the flow path to remove liquid therefrom; and

(d) removing the chemical pulp from adjacent the bottom of the digester.

20. A method as recited in claim 19 comprising the further step (e), after step (c) and before step (d), of causing the downwardly moving slurry to move again to a substantially first diameter portion of the flow path

21. A method as recited in claim 20 comprising the further step of repeating steps (b), (c) and (e) at least once prior to step (d).

22. A method as recited in claim 21 comprising the further step of heating the liquid removed in the practice of step (c), and reintroducing the heated liquid into the digester adjacent where it was removed.

23. A method of introducing a screen assembly into an existing digester for comminuted cellulosic fibrous material without requiring the digester diameter to be increased, the digester having a substantially constant internal first diameter portion of a shell thereof at a location devoid of an agitator, using a screen assembly having a second internal diameter smaller than the first internal diameter, and a transition element providing a transition between the first and second diameters, said method comprising the steps of:

(a) at the substantially constant internal first diameter portion of the shell of the existing digester that is devoid of an agitator, mounting the screen assembly to define a screen cavity internal of the shell, and a return to the first internal diameter below the screen assembly;

(b) forming at least one aperture in the shell adjacent the screen cavity and in fluid communication therewith to allow withdrawal of liquid in the screen cavity that has been separated by the screen assembly; and

(c) inserting the transition element within the shell, above the screen assembly, so that the transition element provides a transition between the first and second diameters that allows a slurry of comminuted cellulosic fibrous material to flow smoothly form above the transition element to below the screen assembly without bridging or hang-up and without need for an agitator.

24. A method as recited in claim 23 wherein step (a) is further practiced by providing at least one of a diverging conical transition and a cylindrical relief plate below the screen assembly providing return to the first internal diameter.

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ABSTRACT OF THE DISCLOSURE

In a vertical digester for producing chemical pulp, or other vessel for treating a slurry of comminuted fibrous cellulosic material, the cost of manufacturing the shell is significantly reduced by eliminating the external step increases in the digester shell. The digester shell has a substantially constant internal diameter from just below the inlet to just above the outlet, screen assemblies being provided by an internal transition (e.g. conical) having an angle of convergence of less than 40° (e.g. about 10-25°) above each screen assembly so that the slurry flows through the transition without bridging or hang-up, and a step increase, or other increase, in diameter back to the first diameter after the screen assembly.

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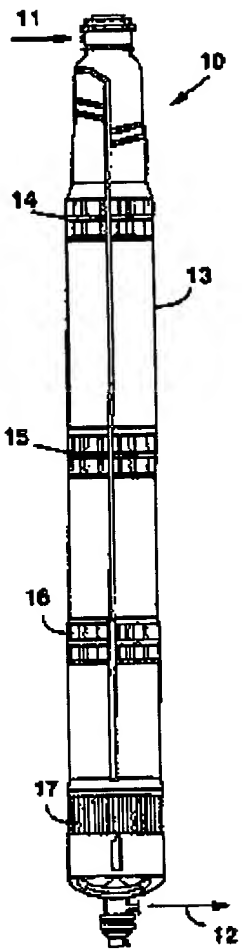

Fig. 1
(PRIOR ART)

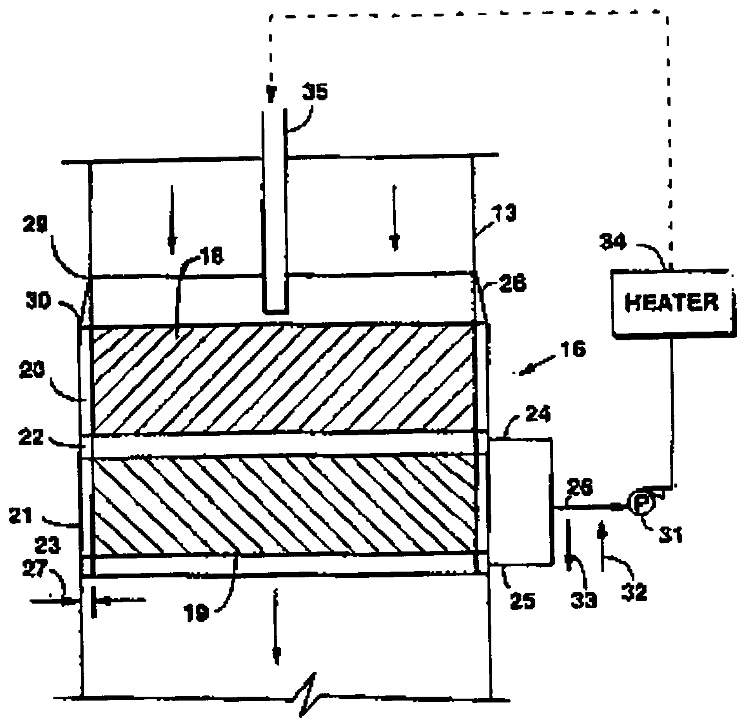

Fig. 2
(PRIOR ART)

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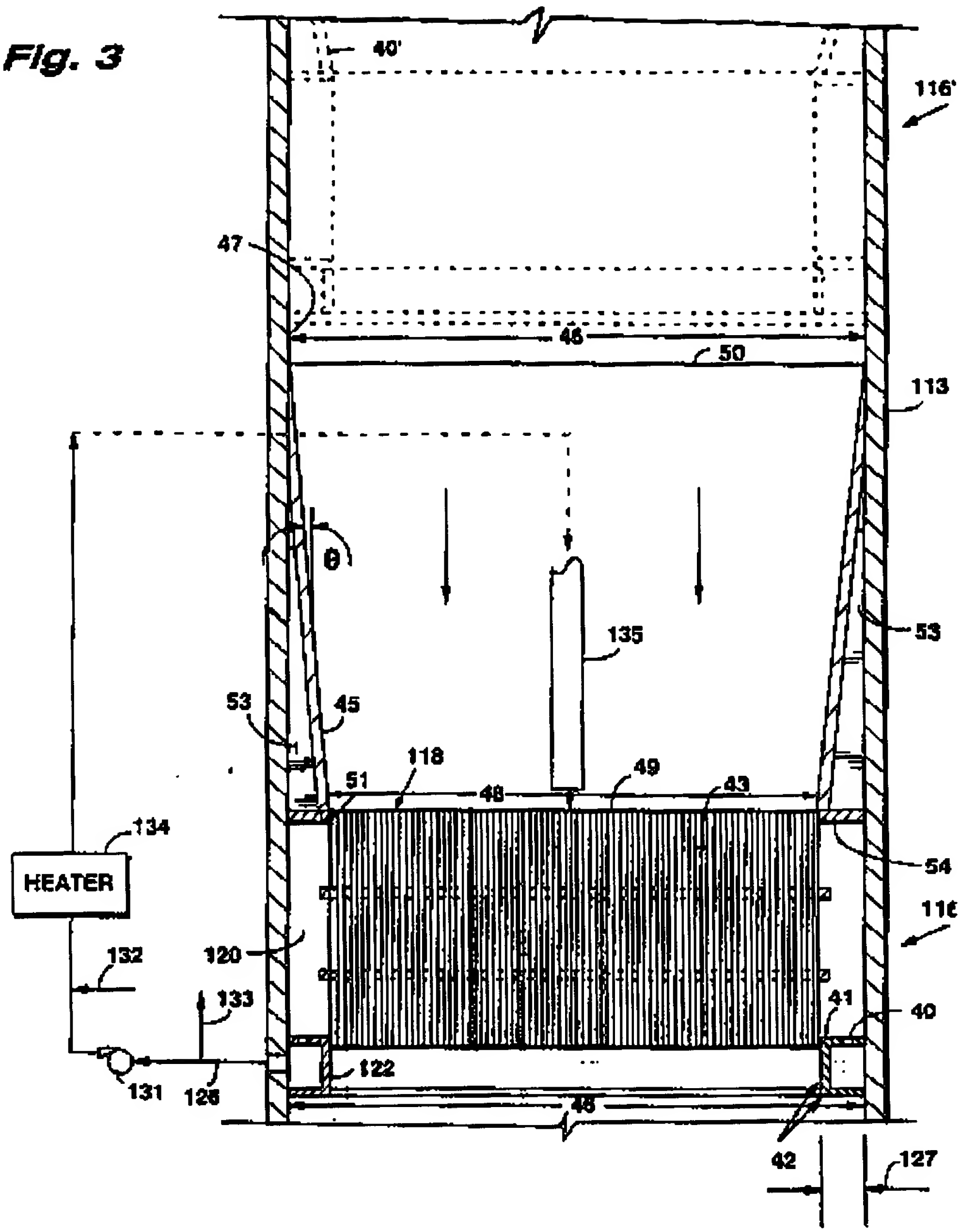
Fig. 3



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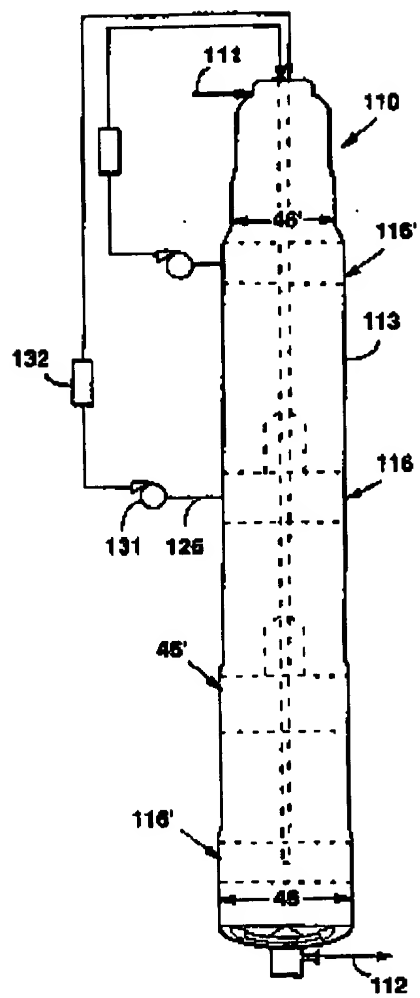

Fig. 4

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Fig. 5

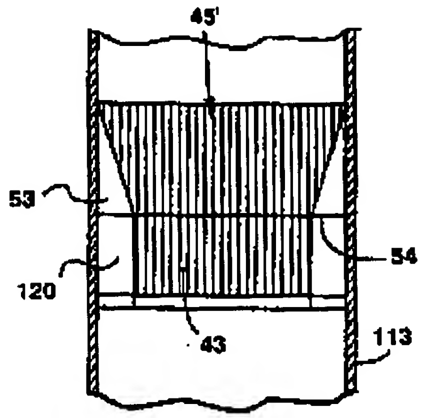

Fig. 6

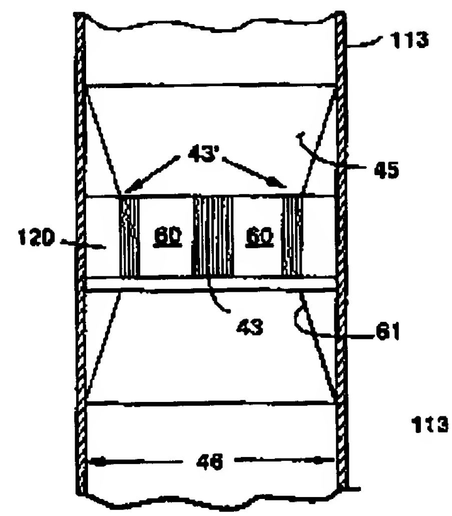

Fig. 7A

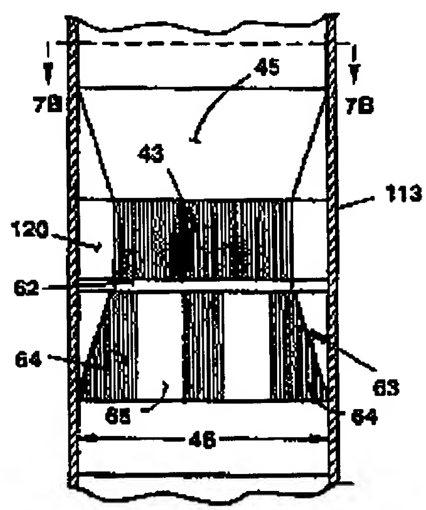

Fig. 7B

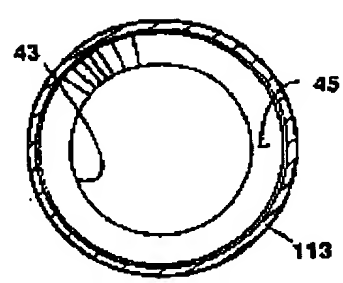

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Fig.8

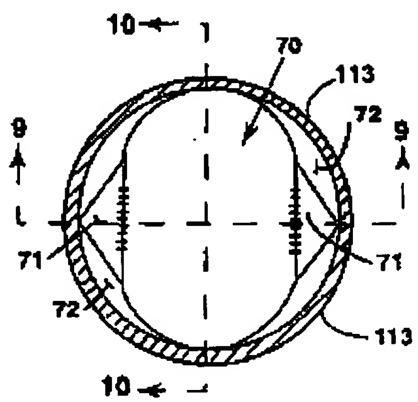

Fig. 9

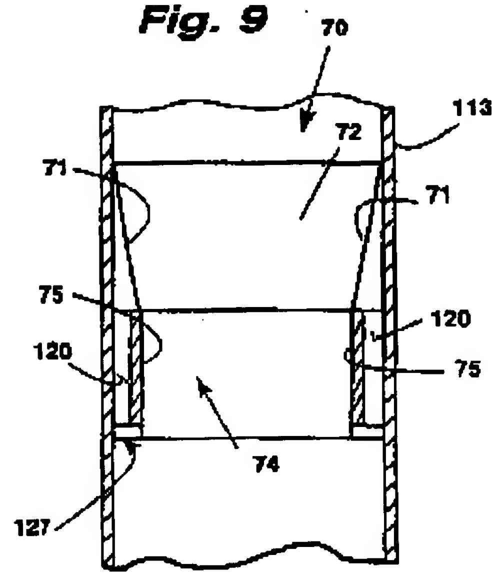

Fig.10

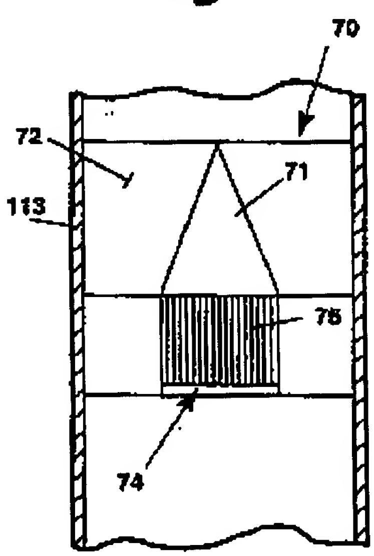

Fig.11

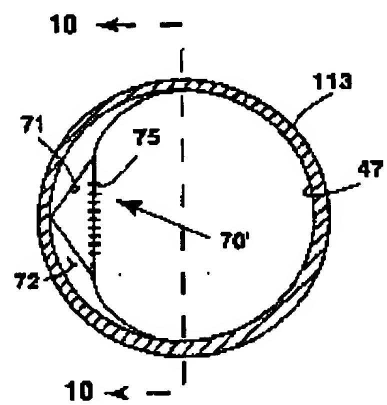

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Fig.12

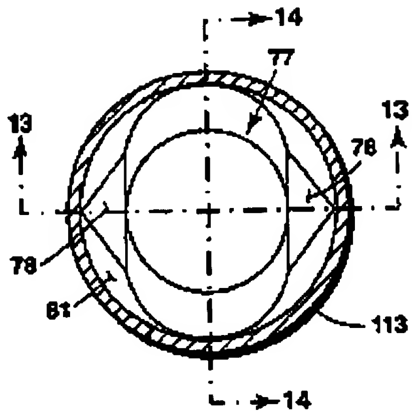


Fig.13

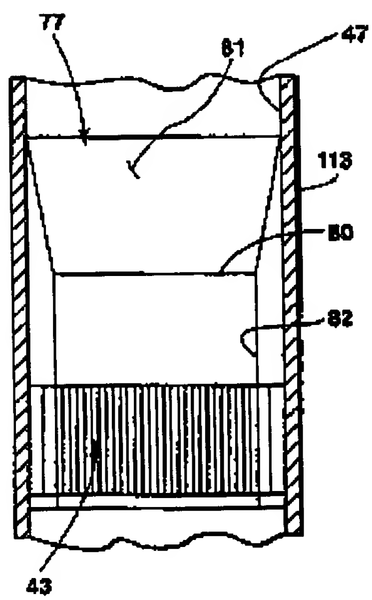
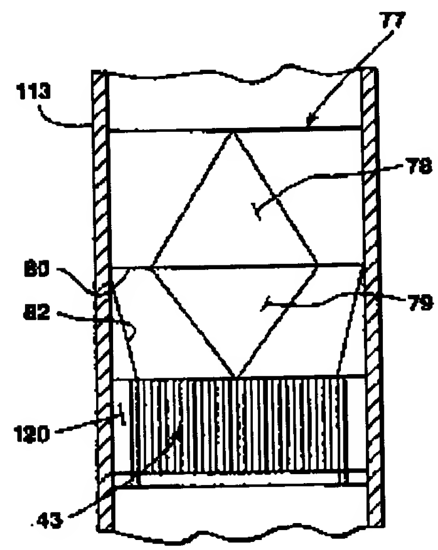


Fig.14



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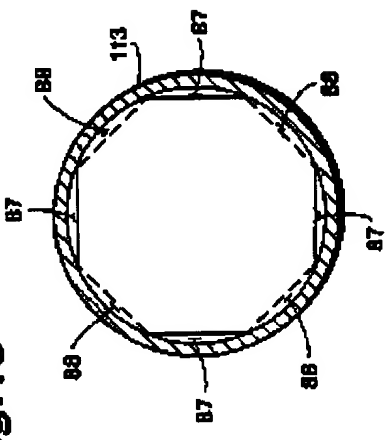

Fig.18

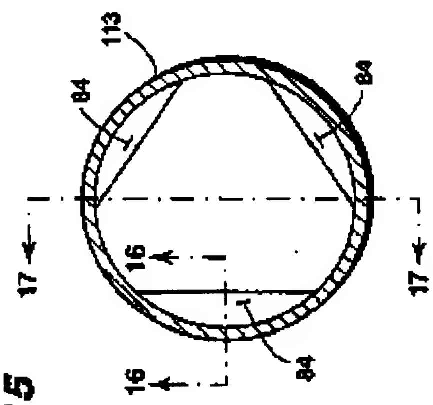

Fig.15

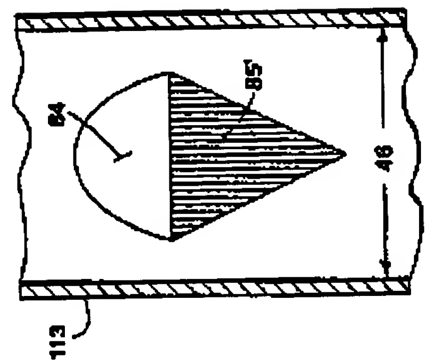

Fig.17B

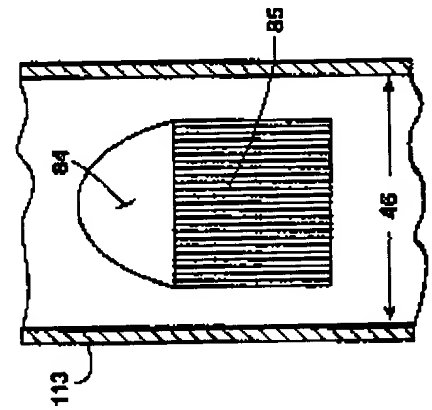

Fig.17A

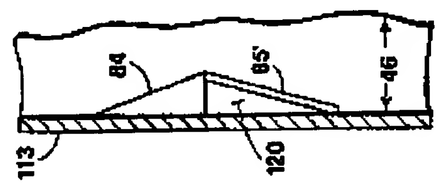

Fig.16B

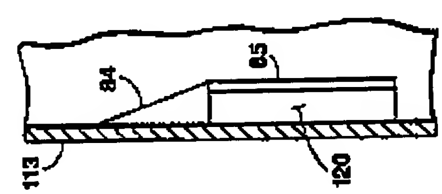

Fig.16A

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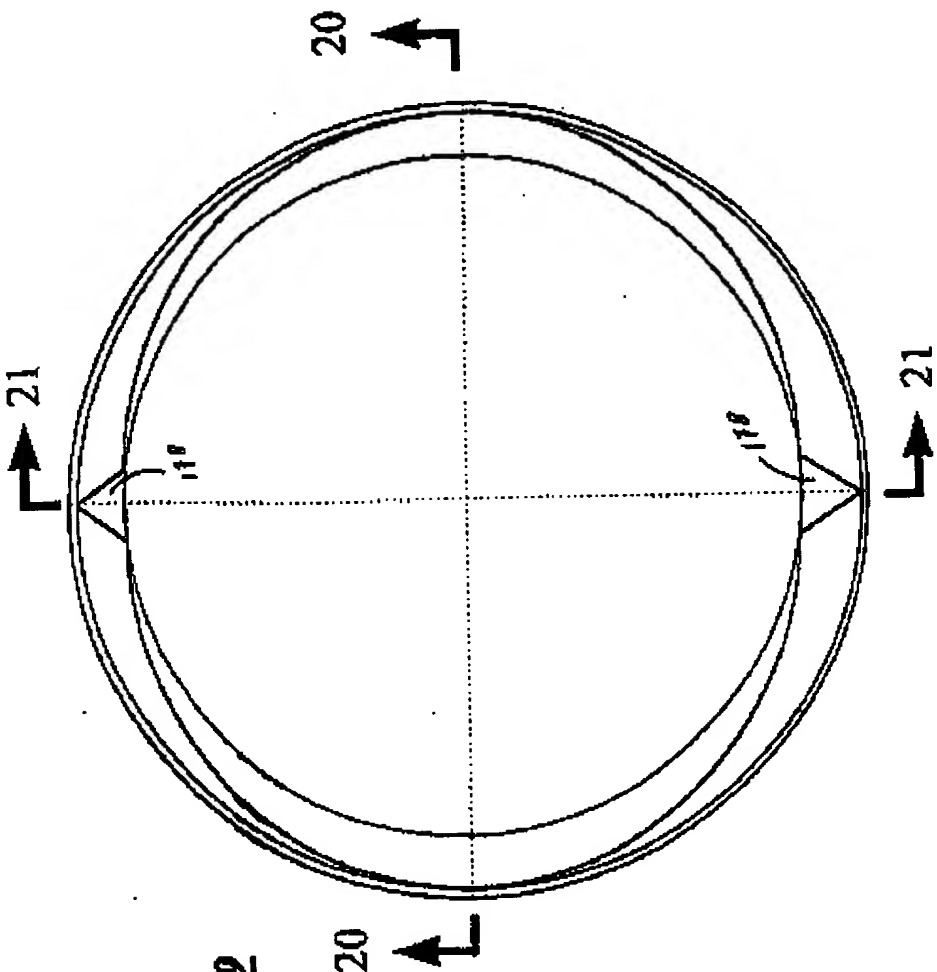

Fig. 19

CA 02243733 1998-07-21

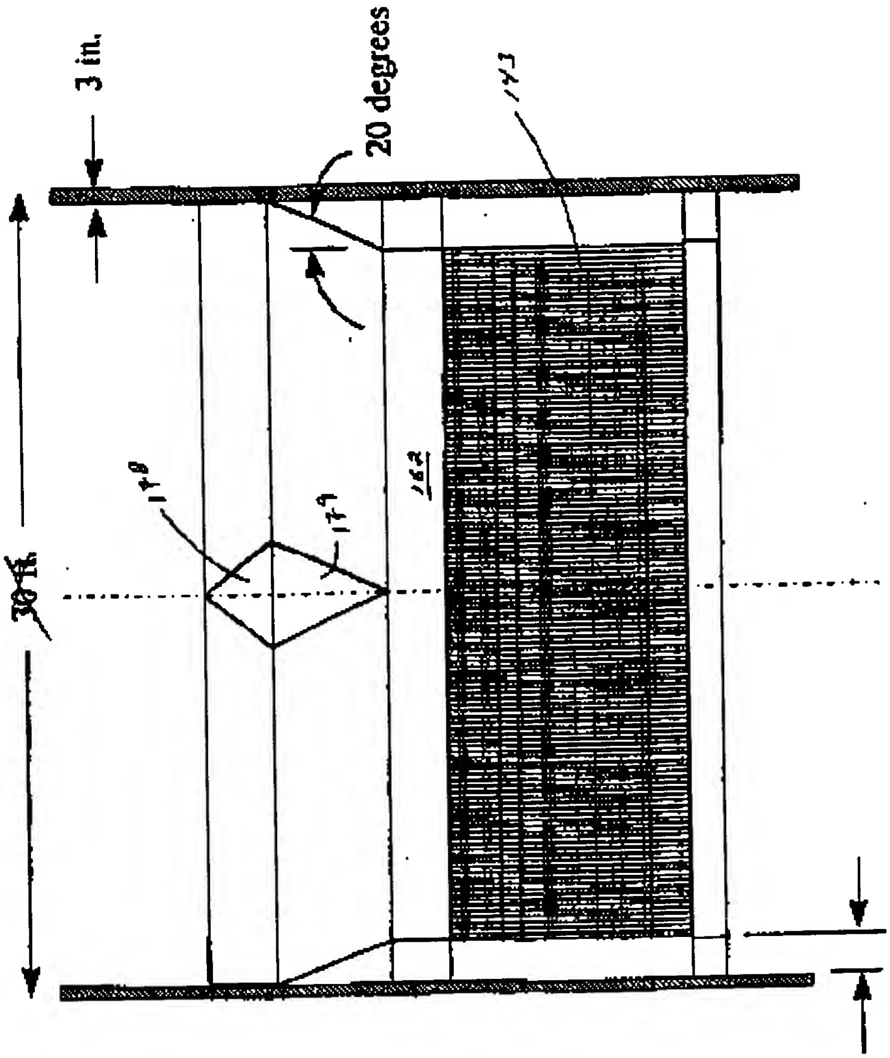

Fig. 20

CA 02243733 1998-07-21

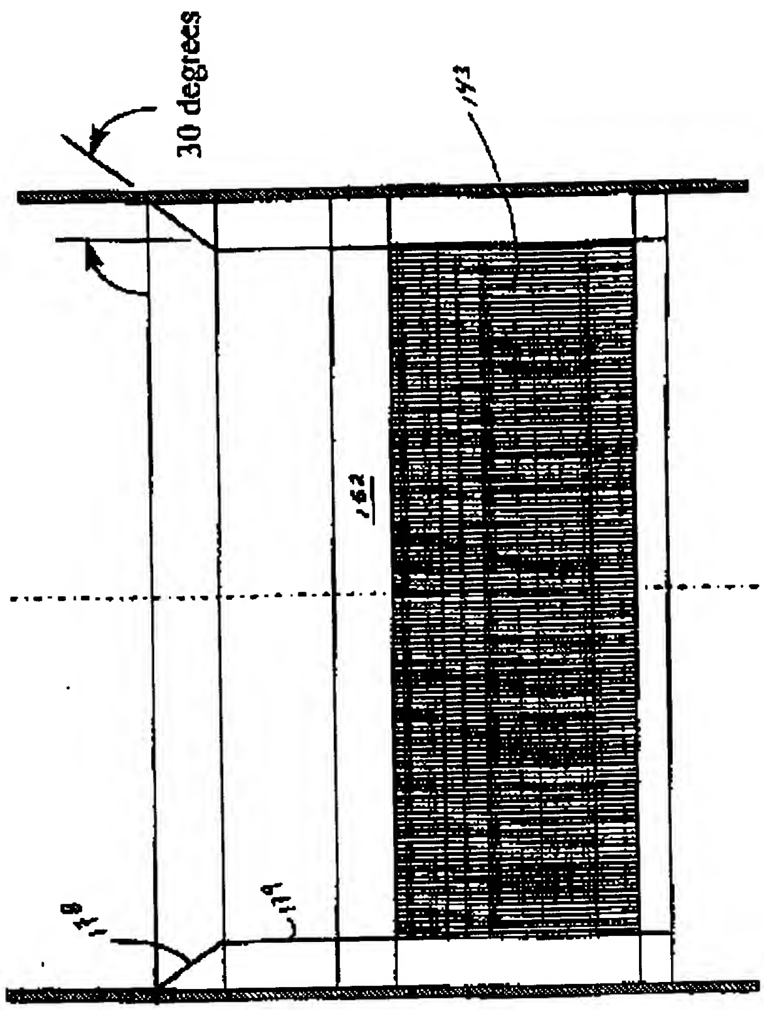

Fig. 21

CA 02243733 1998-07-21

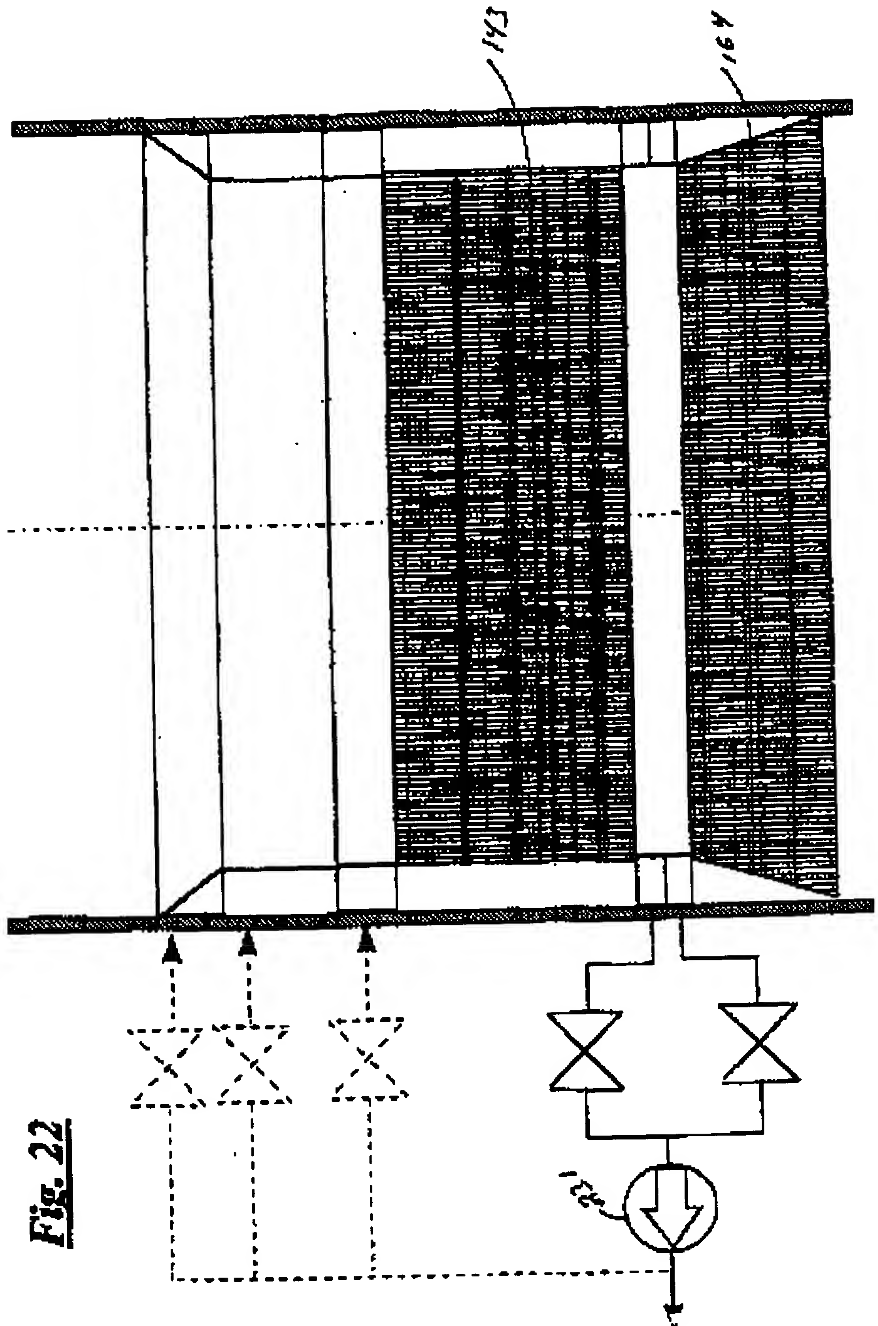

Fig. 22

CA 02243733 1998-07-21

Re: "Diamondback® Centerpipe"

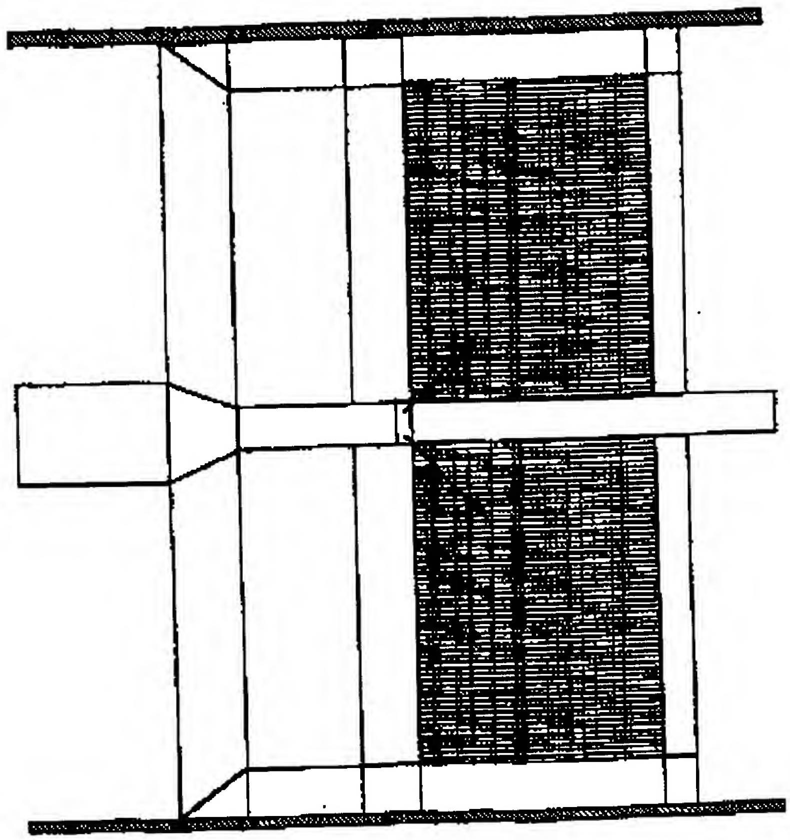

Fig. 23